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The value of clinical judgement analysis for improving the quality of doctors' prescribing decisions

Petra Denig,¹ Rolf Wahlström,² Mark Chaput de Saintonge³ & Flora Haaijer-Ruskamp

Background Many initiatives are taken to improve prescribing decisions. Educational strategies for doctors have been effective in at least 50% of cases. Some reflection on one's own performance seems to be a common feature of the most effective strategies. So far, such reflections have mainly focused on the observed outcomes of the doctors' decisions, i.e. on what doctors do in practice. Studies in other fields have shown that another form of feedback based on the analysis of judgements may be useful as well.

Objectives The objectives of the study were to discuss the principles underlying clinical judgement analysis, give examples of its use in the medical context, and discuss its potential for improving prescribing decisions.

Results Clinical judgement analysis can look behind the outcome of a decision to the underlying decision process. Carefully constructed or selected case material is required for this analysis. Combining feedback on outcomes with feedback based on clinical judgement

analysis offers doctors insight both in what they do, and why or when they do it. It may reveal determinants of decision making which are not available through unaided introspection. Interventions using this combination of feedback for improving doctors' prescribing behaviour have been (partly) successful in 4 cases and unsuccessful in one case.

Conclusions Clinical judgement analysis gives doctors a structured reflection on the decision-making policy, and can help them to improve their future decisions. It may be especially useful for groups of doctors who try to work towards a consensus policy. The approach is not very helpful when simple decision rules are appropriate.

Keywords Clinical competence; decision making; Physicians, family/*standards; prescription, drugs/*standards.

Medical Education 2002;36:770–780

Introduction

Changing routine clinical practice can be difficult. During recent decades, many educational initiatives have been taken to improve drug prescribing. Approaches based on transfer of information (Table 1) are clearly not enough to guarantee that (new) evidence will be implemented in daily practice. There has been

a strong call to change the approach in continuing medical education, and to focus more on the doctors' motivation and active involvement in learning so that they are no longer simply passive recipients of medical information.^{1–4} Several educational approaches have incorporated the principles of adult and social learning, and behavioural change (Table 1).^{5–8} Interactive learning, professional stimulation, self-directed learning, audit and feedback are some of the features of newly-developed strategies for continuing medical education. It is becoming clear that the implementation of new evidence in practice can be stimulated when doctors first identify deficiencies in their own knowledge and performance, and then critically evaluate new information.^{2–4} Doctors must see the need to change, learn and accept new ideas, be able to change, and implement reinforcements to sustain these changes.^{9,10} Experience-based knowledge and expertise should be recognised and considered in the learning process.¹¹ Another

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Key learning points

Unaided introspection does not give doctors accurate insight in how decisions are made.

Clinical judgement analysis gives doctors a structured reflection on their decision making policy.

Clinical judgement analysis can help groups of doctors working towards a consensus policy.

Feedback based on clinical judgement analysis has been successful in improving prescribing decisions in practice.

development is to focus on the process of judgement and decision making in practice. This has resulted in specific training programmes or support strategies (Table 1). Studies of judgement and decision making have provided ideas on how professional decisions might be improved, for example, the theory that doctors should learn how to include relevant information and avoid common reasoning errors.^{12,13} To help them, decision aids and decision support systems have been developed.^{14–16} These include alerting, reminding or critiquing systems; other systems provide assistance or suggestions when making diagnostic or treatment decisions.¹⁷ Besides these single strategies, multifaceted programmes have been developed that combine approaches which may be based on different principles.¹⁸

The effects of many of these educational strategies have been summarised and compared in more than 20 systematic reviews of rigorous studies.^{15,16,18–22} For improving prescribing, the more effective strategies include interactive meetings and outreach visits, reminders and decision support systems, audit and feedback, and combinations of these strategies. However, it

is clear from these reviews that no single educational strategy can be relied upon to improve doctors' performance. The most successful educational strategies focusing on doctors' prescribing behaviour have shown effect in approximately 50% of the reported studies.²¹

A common feature of the more successful strategies, such as outreach visits, reminders, audit and feedback, is that they usually provide an element of reflection on one's own performance. This reflection step is also recognised in the experiential learning cycle.²³ So far, such reflections have focused mainly on the observed outcomes of the doctors' decisions, i.e. on what doctors do in practice. For example, tables or graphs of individual prescribing patterns are presented and discussed.^{24–26} This outcome feedback helps doctors to identify deficiencies in their performance, and can be used to reinforce the process of behavioural change. Studies in other fields have shown that another form of feedback based on an analysis of (clinical) judgements may also be useful.^{27–29} Clinical judgement analysis looks behind the outcomes to the underlying process. When used for giving feedback to doctors, it helps stimulate insight into the underlying basis for decisions and allows their quality to be improved.^{30–33} It can be seen as an approach which combines ideas from adult learning, behavioural change and decision making theory. In this paper we will discuss the principles underlying clinical judgement analysis, some examples of its use in the medical context, and its potential for improving prescribing decisions.

What is clinical judgement analysis?

The model that guides most work on clinical judgement analysis is the so-called 'lens-model', originally developed by Brunswik in 1952.³⁴ Based on this model, judgements require the simultaneous assessment of

Table 1 Approaches for continuing medical education

Approaches based on the transfer of information:

- Educational material (journals, books, reviews, drug bulletins, practice guidelines)
- Oral presentations (conferences, courses, lectures, expert led teaching)

Approaches based on principles of adult & social learning, and behavioural change:

- Interactive learning (outreach visits, small group discussions, local consensus building)
- Professional stimulation (examples of successful changes from peers, comentering, opinion leaders)
- Self-directed and experiential learning (portfolio-based learning, 'on-the-job' learning, problem-based learning)
- Audit and feedback on performance (self assessment, structured reflection, peer review)
- Reminders (verbal, paper or computerised reminders)
- Marketing or tailoring approach (identifying and addressing factors enabling or impeding change)

Approaches based on decision making theory:

- Training in clinical reasoning (learning a systematic approach, de-biasing judgements)
- Decision support (decision trees, decision rules, computerised support systems)

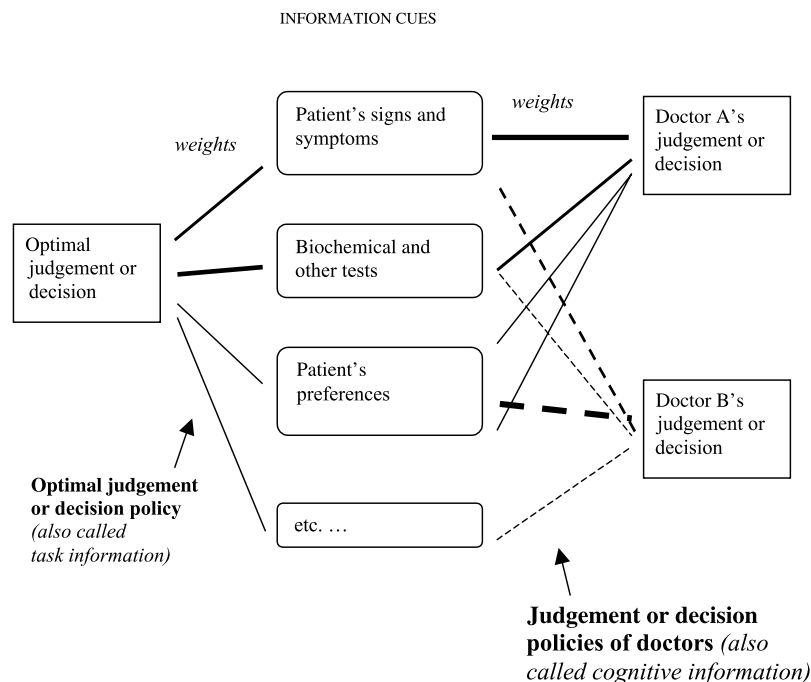


Figure 1 Model for judgement analysis.

information from a number of cues (Fig. 1).³¹ Each information cue is related to a person's judgement through a weight expressing the relative importance of that cue. These weights can be inferred from a series of actual judgements using multiple regression procedures or alternative models which capture the relationship between cues and judgements.^{31,35} This technique is known as judgement analysis.^{31,32} Together the weights constitute the *judgement policy*. The policy of an individual person shows how he or she appears to weigh the various information cues for the judgements that have been analysed. It is important to realise that these policies provide a representation of the judgement process, but do not reveal this process directly. If the optimal judgements are known for the cases included in the analysis, one can calculate the optimal policy or rule (Fig. 1).

In the medical context, clinical judgement analysis has mostly been applied to improve understanding of diagnostic judgements,³⁰ however some studies have focused on the process of making prescribing decisions.^{36–38} It should be noted that although judgements are not synonymous with decisions, it is assumed in such studies that a prescribing decision is based on the evaluative judgement of possible (treatment) options for a patient.³⁹ Consequently, judgement analysis methods have been applied for the analysis of decisions. To reach a prescribing decision, a doctor collects consciously or unconsciously a set of information. These information cues may include symptoms and signs of the patient,

expectations of alternative treatments, other or previous medication used by the patient, and possible co-morbidity. Other less bio-medical cues, such as patient preferences, willingness of doctor or patient to choose a non-pharmacological treatment, patient's age, occupation or personality, may influence the decision as well. When the process by which therapeutic decisions are made is available for inspection, such decisions can be effectively modified. Surprisingly, doctors are often not able to accurately describe how they make everyday decisions.^{36,37,40–42} They may be aware of the most important clinical information they attend to, but usually think that their decisions are influenced by more clinical cues than seems to be the case.^{37,38} There may be several reasons for this, such as retrospective inaccuracy, idealisation, and inability to describe multidimensional tasks.⁴³ Clinical judgement analysis overcomes some of these problems by analysing the responses of doctors to cases as a whole. This may, on one hand, reveal cues that a doctor is not aware of using or believes to be irrelevant or socially unacceptable. On the other hand, it can show that some cues which are considered clinically relevant do not appear to influence the final decision.^{30,36}

Giving feedback based on clinical judgement analysis

Feedback based on clinical judgement analysis can help doctors reflect on the influence and relevance of the

Figure 2 Example of patient case.

Patient case 1*

A 32-year old woman visits your surgery. She has had a worsening sore throat for 3 days with a *low fever*. She has difficulty swallowing and some loss of voice. There is no nasal congestion. *Cough* is present but non-productive. The pharynx is *erythematous without exudates*. There is also *minimal anterior cervical lymphadenopathy*

Would you prescribe an antibiotic?

* Other cases in the series would vary on the pieces of information given in italics.

information cues in a structured manner, as the information in the cases is given in a predefined format. The task of constructing and analysing this case material can be complicated and skilled educators are usually required. What is needed is a series of cases for which the doctor makes judgements or decisions. These cases vary on a number of case characteristics, i.e. the information cues (Fig. 2). Using the judgements or decisions made by the doctor as outcome variable and the case characteristics as predictor variables, one can determine the relative weight or influence of each of those cues. Bar graphs showing the relative importance of the cues can be given as feedback to the doctor (Fig. 3). In this example, doctor A can see that she mostly prescribes antibiotics for patients with sore throats having pharynx exudates, tender lymph nodes and high fever. Doctor B, on the other hand, is more likely to prescribe antibiotics for older patients with a fever but no cough. This type of feedback, showing decision policies, is often referred to as '*cognitive feedback*' to differentiate it from outcome feedback.³⁰ Cognitive feedback shows when and why certain decisions are made, whereas outcome feedback shows what has been decided. (Figure 2) (Figure 3)

The cases used for clinical judgement analysis can be a representative sample of actual cases, vignettes based on such cases, or a series of hypothetical case vignettes. Usually case vignettes are used, as these allow for a well-controlled comparison between individuals. It is important that the cases are realistic and include all the relevant information for making the judgement or decision.⁴³ Case vignettes can never fully reflect the complexity of real cases, however, as they lack visual cues and doctor-patient interaction. Their value is restricted to those situations that can be adequately described on paper. They are not suitable for measuring technical skills or interpersonal attributes, but can be an efficient instrument for evaluating competence and for elucidating the clinical decision making process.^{44,45} For diagnostic and treatment decisions high correlation

has been found between decisions made for real patients and case vignettes.^{45,46} The advantage of case vignettes is that the same standardised cases can be presented to different doctors, allowing for direct comparisons and interpersonal learning.

The number of cases used for clinical judgement analysis must be limited, and the number of information cues that vary from case to case should be kept small. Although it has been suggested that doctors may be willing and able to deal with up to 60 cases and eight cues,³¹ and some doctors have dealt with up to 130 cases and 13 cues,³⁹ it is our experience that most doctors are not prepared to evaluate much more than 30 cases and up to 6 cues in one session. The cues selected could be those relevant for making optimal judgements or decisions, or those likely to trigger suboptimal judgements or decisions. Cues may be included that are used by only some of the doctors. Also cues could be included that are likely to show the greatest variance between doctors, or between doctors and a consensus policy. In this way, providing feedback on these cues will facilitate the doctors' understanding of ways in which they can improve their use of the cues and thereby their future judgements or decisions.³¹ Other information that needs to be included can be held constant across all cases.

It is important to realise that the variety of the cases, the range of the cue values, and the way in which the judgements or decisions are measured may have implications for the analysis of the material and the validity of the feedback. Some guiding principles on constructing, analysing and presenting case material for feedback are given in the appendix. More detailed information is available in handbooks on judgement analysis.³¹

Three learning strategies can be followed when giving feedback: single-sided, double-sided, and interpersonal learning. In single-sided learning, participants only get feedback on their individual judgement or decision policy. This may show discrepancies between the information cues they think influence their judge-

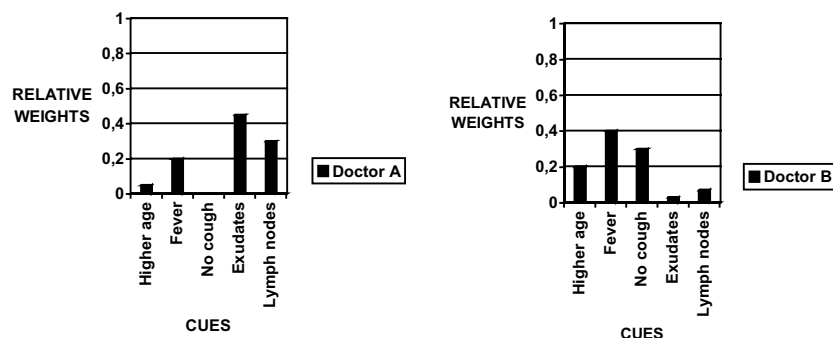


Figure 3 Example of feedback graphs: importance of age, fever, cough, pharyngeal exudates and tender lymph nodes on the decision to prescribe an antibiotic for a sore throat.

ments or decisions, and the ones that actually are of influence. In other words, it increases self-insight into the judgement or decision policy. When the optimal policy is added to the individual feedback, this is called double-sided learning. It shows possible discrepancies between how judgements or decisions are made and how one should make them. When there is no objective way of determining the optimal policy, the policy of one or more experts can be used as a substitute. In non-medical fields, combining individual cognitive feedback (also called *cognitive information*) with the optimal policy (also called *task information*) was more effective than giving cognitive feedback only.^{47,48} This parallels findings regarding the use of outcome feedback in the medical area. Outcome feedback presented in combination with clear recommendations is more likely to be effective than outcome feedback without recommendations.^{49,50} Studies in the non-medical field suggest that in some cases providing the optimal policy only may be sufficient.⁴⁸ Interpersonal learning occurs when the policies of several peers are compared and discussed. It may expose situations in which doctors agree on particular judgements or decisions but rely on significantly different arguments to arrive at that judgement or decision.^{39,51} In such group settings, one can try to reach consensus on the best policy. Experiments outside the medical field showed that judgement analysis can improve the accuracy of consensus policies in small groups.⁵²

Cognitive feedback on prescribing decisions

Cognitive feedback, i.e. feedback based on clinical judgement analysis, can be given on different types of judgements or decisions. With regard to prescribing there are various types of decisions made by doctors. Each doctor has a chosen group of drugs from which he or she normally prescribes.⁴¹ Occasionally the doctor will make a decision to adopt a new drug or discard an

old drug from this set. Cognitive feedback can give insight on how a doctor weighs up aspects of the drug – such as efficacy, side-effects and costs – in order to decide whether the drug is worth prescribing. An example of such feedback can be found in a study conducted by Shiels in Australia (discussed by Schwartz and Griffin³³). Doctors and medical students had to choose between hypothetical cortisone preparations. These preparations varied with respect to the severity and frequency of 6 relevant side-effects (myopathy, hirsutism, weight increase, hypertension, cushing face, and gastric ulcer). The goal was to teach participants a method for combining the information on various side-effects to choose the preferred drug.

Another type of decision is made when a doctor is confronted with a specific patient and has to decide what to prescribe for that patient. Cognitive feedback may then focus on specific characteristics of the patient case, and how these case characteristics influence the doctor's treatment decisions. The European Drug Education Project, for example, used this type of feedback.^{53–55} In this project 3 series of patient cases were developed, and doctors had to write down what they would prescribe in each of the cases. One series presented various patients with asthma exacerbations, and the feedback focused on the influence of age, severity of respiratory symptoms, cough and phlegm, fever, and Peak Expiratory Flow (PEF)-values on the decision to prescribe antibiotics and/or oral corticosteroids. The second series focused on the role of symptoms, PEF-values, and current levels of drug use on the decision to change maintenance treatment for asthma patients. The final series consisted of patients with urinary tract infections, and feedback was provided on the influence of age, previous episodes, severity of symptoms, blood in urine, and circumstances of the visit on the choice and duration of drug treatment. Personal feedback was provided and discussed in small groups of peers. An optimal decision policy was also shown in 2 of the 4 countries. The goal was to give

doctors insight into the case characteristics triggering suboptimal treatment decisions, and to help them to learn how to focus on the relevant information in the future.

Effects of giving feedback on clinical decisions

Not many studies have been conducted testing the effect of feedback based on clinical judgement analysis. Several studies were conducted in restricted settings. Three of these studies involved students making diagnostic judgements and showed that the optimal policy combined with personal cognitive feedback was less effective than the optimal policy combined with personal outcome feedback.^{56–58} Another was the previously mentioned study by Shiels in which doctors and medical students had to choose between hypothetical cortisone preparations.³³ All subjects learned equally well when given personal cognitive feedback combined with the optimal policy, but doctors also benefited from outcome feedback combined with the optimal policy (Table 2). Since the effect of an educational strategy on (clinical) tasks is likely to depend on the subject's experience with those tasks, it is difficult to extrapolate findings from these settings to doctors who make decisions for situations they actually encounter in practice.

The studies of the European Drug Education Project and a study by Poses *et al.* evaluated the effect of cognitive and outcome feedback on actual clinical decisions.^{43–55,59} Poses *et al.* studied the impact of a combination of cognitive and outcome feedback for improving doctors' judgements of the probability of streptococcal pharyngitis for patients with sore throats.⁵⁹ The goal was to improve the decisions for antibiotic treatment by improving diagnostic judgements. The diagnostic judgements did improve after the intervention, but the proportion of patients treated with an antibiotic did not change (Table 2). In other words, the combination of cognitive and outcome feedback was effective, but apparently the decision to prescribe for sore throats was not wholly triggered by the expected probability of streptococcal pharyngitis. In the European Drug Education Project personal cognitive feedback was combined with various other types of feedback in 4 countries.^{53–55} The effects varied between the countries and the therapeutic subjects addressed, but were not clearly connected to a specific combination of feedback provided (Table 2). The combination of cognitive and outcome feedback either with or without an optimal decision policy was effective in improving actual prescribing behaviour for uncomplicated urinary tract infections among patients in Sweden

and the Netherlands.^{53,54} For improving the treatment of asthma, similar combinations of feedback were partially effective in the Netherlands and Norway but not in Sweden.⁵⁵ Cognitive feedback was provided without outcome feedback in Slovakia only. Several improvements were observed after the intervention, but these did not reach statistical significance. This may be due to the small number of doctors participating in this country.⁵⁵ There were no indications that the decision policies used by doctors or the insight provided by discussing the policies was different in the various countries.⁶⁰ There are, however, other differences between the countries which may explain the differences in effect of the intervention programme, for instance regarding the culture of continuing medical education and regarding the general trends in prescribing.⁵⁵

In conclusion, the studies focusing on improving doctors' prescribing behaviour have mostly combined cognitive feedback with outcome feedback, making it difficult to draw firm conclusions regarding the effect of this feedback alone. From previous reviews, it can be expected that providing only outcome feedback on prescribing in an educational programme will be effective in up to half of the cases.²¹ The combination with cognitive feedback may have some additional effect, as this was successful in 3 cases, partly successful in one case, and unsuccessful in one other case.^{53–55} This is comparable to results of the most effective strategies identified for improving prescribing behaviour.²¹

Strengths and limitations

The strength of giving cognitive feedback on clinical decisions lies in its potential to reveal underlying determinants of decision making.³⁰ It can show that a treatment decision is associated with certain irrelevant information cues or that it is not associated with certain relevant cues,^{30,36,60} and it can therefore help doctors to improve their decision making skills.^{53–55} Cognitive feedback may also help doctors to become more consistent in applying a certain decision policy. In a learning setting, clinical judgement analysis provides reflection which is based on systematic analysis instead of mere introspection. It ties in with the experiential cycle of learning,²³ offering observations in the form of analysed decisions that can be the object for individual or group reflections. This structured reflection can improve the validity of the consequent revisions, which can subsequently be tested in real world tasks.

The value of cognitive feedback based on clinical judgement analysis will vary with the characteristics of

Table 2 Studies testing the effect of cognitive feedback on decision making of doctors

Author	Subjects	Behaviour	Outcome	Type of feedback	Result;
Shiels in Schwartz ³³	Doctors	Choose the best cortisone preparation	Preparation chosen	POF + OPF	+
Poses ⁵⁹	Doctors	Judgement of probability of streptococcal pharyngitis and treatment of sore throats	Probability estimate and actual antibiotic treatment	PCF + OPF OOF + PCF	+ + (probability) – (treatment)
Veninga ⁵⁵	Doctors	Treatment choice asthma – Sweden – Norway – Netherlands – Slovakia	Treatment of actual patients	POF + PCF POF + PCF POF + PCF + OPF	– +/ +
Veninga ⁵³	Doctors	Treatment choice for urinary tract infections	Treatment of actual patients	POF + PCF + OPF	~ +
Stalsby ⁵⁴	Doctors	Treatment choice for urinary tract infections	Treatment of actual patients	POF + PCF	+

POF = personal outcome feedback; PCF = personal cognitive feedback, i.e. feedback of personal policy; OPF = optimal policy feedback; OOF = optimal outcome feedback

the task as well as with the subject's experience. Obtaining detailed feedback on simple or previously known decision policies is not very helpful.³⁰ In a study of medical students, Tape *et al.*⁵⁷ surmised that the lack of additional effect from individualised cognitive feedback might be due to the fact that the optimal policy presented to all participants was very simple and easily adopted by the students. In the European Drug Education Project, a similar situation may have occurred regarding the treatment of urinary tract infections.⁵³ A substantial number of doctors prescribed exactly the same treatment for patients with urinary tract infections. In other words, none of the information cues included in the cases triggered any variation in the treatment choice. For these doctors, personal cognitive feedback was superfluous, and they may have benefited only from learning the optimal decision policy. This is consistent with some findings from other fields.⁴⁸ Furthermore, in one study outside the medical field it was suggested that careful analysis and introspection is more helpful for analytical than for intuitive decisions.⁶¹ For medical practice, however, it has been argued that for intuitive decisions an objective description can provide the doctor with insights that may lead to improvements.⁶²

In general, it could be said that when there is an agreed consensus regarding the optimal decision policy this should be taught and additional cognitive feedback may be useful when doctors are not fully aware that they are not working according to the optimal policy. If a doctor knowingly uses an alternative policy – not agreeing with what is

considered the optimal policy – there is not much sense in giving individual cognitive feedback. When there is no agreed optimal decision policy, clinical judgement analysis can be an effective way to discover what, for instance, others or experts do when making decisions.

It is not yet clear what is the best method for providing cognitive feedback to doctors. In the study by Poses *et al.*,⁵⁹ an interactive teaching programme was used. Computer programmes have the advantage of providing immediate feedback and can be used in a self-learning approach. Most doctors, however, do not immediately understand how to interpret graphs showing the relative importance weights of a number of information cues on their decisions. This may be due to the static nature of the description, which is derived from a series of cases and is not directly related to one recognisable case. If there is a comparison with the ideal policy or with policies of other individuals, it may become easier to interpret a graph showing your own policy. In the European Drug Education Project, cognitive feedback was provided in an interpersonal learning setting.⁵⁵ This made it possible to discuss the feedback material with others and with the assistance of a moderator who was able to explain and interpret the feedback graphs. Group discussions bring in a wider and shared practical experience, thus broadening the basis for reflection. In groups working towards a consensus, cognitive feedback may have an additional value. There is evidence to suggest that group discussions and group judgements may benefit especially from this type of feed-

back.⁶³ It can improve agreement by revealing differences in decision policies based on the same series of patients seen by different doctors.⁶⁴

Cognitive feedback is obviously limited to those information cues that are included and varied in the case descriptions. It is essential to give feedback on both the decision you want to support and on the aspects that are used by doctors to make this decision. Poses *et al.*⁵⁹ demonstrated that giving feedback on aspects that determined the probability judgement of sore throats did improve those diagnostic judgements but did not change treatment decisions. The assumption that the treatment decisions were based on those probability judgements might have been incorrect.⁵⁹ The first step in constructing case material for cognitive feedback should be a thorough investigation of the information cues that are used and that should be used for making the treatment decision. A combination of methods is often needed to identify the appropriate cues.³¹ Surveys and interviews with representative samples of doctors and experts will provide the cues that they are aware of using or that they think should be used. Open questions, critical cases, or lists of possible cues could be used to elicit relevant cues. The technique of thinking aloud while making decisions may help to reveal cues that the doctor is using. Existing medical records and databases can be used to determine the possible relevance of those cues already recorded in these databases. Review of the published evidence can provide cues that should be used for a specific decision. Some information cues, however, may be difficult to include in the cases, such as the individual patient's worries or demands. Other predictors cannot be included, such as the doctor's propensity to prescribe certain drugs.

In conclusion, cognitive feedback based on clinical judgement analysis is one of the strategies that can be used to improve the quality of prescribing decisions in practice. Combining outcome feedback with cognitive feedback may offer doctors insight both in what they do and why they do it. Cognitive feedback is not suitable to support one specific decision for an individual patient, but it may help doctors to develop a more adequate decision policy for a group of patients. It may be especially useful for groups of doctors trying to work towards a consensus policy. It is suitable for complex tasks for which individuals or groups must collate, prioritise, and combine different information cues. The cues that can be included, however, are limited to those that can be described adequately on paper.

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Appendix: Guidelines on Constructing, Analysing and Presenting Case Material

Representative vs. experimental Design

There are basically two different approaches for selecting cases to be presented: (1) using vignettes based on a representative sample of actual cases; or (2) constructing case vignettes using an experimental design. The advantage of a representative sample is a high content and construct validity, whereas the advantage of an experimental design is that one can minimise the number of cases required to conduct a reliable analysis (see also number of cases). Sampling actual cases requires careful comparison of means, standard deviations, ranges, and inter-correlation of the information cues in the population and in the final sample. Especially when a small number of cases is sampled, there is a risk that certain combinations of cues or specific levels of cues are not represented and mislead-

ing conclusions on the relative weight of cues might be drawn. Also when generating hypothetical cases it is important to take ranges and inter-correlation of information cues in the actual patient population into account, otherwise non-realistic cases will be generated, which reduce the validity of the study.

Number of cases

In order to reach reliable estimates of the relative importance of each cue, at least 5 times as many and ideally 10 times as many cases as cues should be utilised. To study possible interaction effects between the cues even more cases are required. When using an orthogonal design to generate cases, a minimum number of cases can be generated depending on the number of cues and the number of levels on which each cue is varied. Software packages are available that generate cases for judgement analysis, often using orthogonal designs (see *Computer Programmes*).

Ranges of cue levels

The range for cue levels (in the selected case series) should be similar to a realistic range. Unrealistic levels for a cue will generally lead to an overestimation of its importance.

Cue presentation

Cues may be presented in two formats: (1) quantitatively (using abstract scales or actual units in which the cue can be measured); and (2) verbally (describing the cue's level, for example, mild/moderate/severe or male/female). Numerical representation has the advantage of providing precise values, which may facilitate more consistent judgements. Verbal representation is sometimes easier to interpret, but may be difficult to translate into numerical values for analysis. Cases constructed for educational purposes are best presented as they would be to doctors in actual practice.

Judgement or decision measurement

Doctors' judgements or decisions must be measured in a way that is congruent with the way in which they are made in actual practice. Judgements can be rated on a scale, for example as the probability of something being true or a scale ranging from lowest/most negative judgement to highest/most positive judgement. Judgements and decisions can also be determined categorically by ranking several possibilities or choosing the most preferred one. The choice between ratings and categorical judgements or decisions has consequences for the method of analysis (see below).

Display feedback

Cognitive feedback is commonly displayed using graphics. Bar graphs illustrating the relative importance of cues are relatively easily understood. Line graphs may depict non-linear relationships between cues and judgements. In addition, figures for the predictability of judgements, and the mean or range of the judgements, may be provided as feedback.

Analysis

Clinical judgement analysis usually involves multiple regression methods, although other models and techniques can be used.³⁵ When analysing judgements that were scored on a continuous scale using a linear regression model, an equation is captured which best predicts the judgements. If all cues are expressed on similar scales the raw beta-weights indicate the relative importance of the cues. When different scales of measurement are used, however, any comparison of the relative magnitude of the raw beta-weights is meaningless. Instead, standardised regression coefficients should be calculated. To make coefficients easier to interpret they can be transformed into relative weights that sum to 1. When cues are *inter-correlated* other approaches may be necessary, for instance, calculating usefulness indices to assess the contribution of each cue in a simultaneous regression approach.³¹ For analysing *dichotomous or categorical* judgements or decisions on the basis of either continuous or categorical cues one cannot use ordinary regression analysis. Instead, logistic multiple regression analysis or linear discriminant analysis must be used. Producing relative weights is more difficult in this case, however several alternatives that express the relative importance of the various cues have been proposed for these methods of analysis.³¹

Computer programmes

Several computer programmes are available for conducting judgement analysis. Programmes such as POLICY PC and GLENS were developed specifically for this type of analysis. POLICY PC performs all needed steps for judgement analysis, including the generation of cases, computation of relative weights, and production of numerical and graphical cognitive feedback. The program can manage up to 8 judges, 8 cues, and 100 cases, at the same time. GLENS conducts different types of analyses, and handles up to 100 cases and any number of cues. Some of the more widely available statistical packages include algorithms for conducting analyses for orthogonal designs.

